T.O. 33K6-4-15-1

TECHNICAL MANUAL

CALIBRATION PROCEDURE

FOR

MICROMETERS, MICROMETER HEADS, CALIPERS AND DEPTH MICROMETERS

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MICROMETERS, MICROMETER HEADS, CALIPERS AND DEPTH MICROMETERS

1 CALIBRATION DESCRIPTION:

Table 1.

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
Length	Range: 0 to 36 in 0 to 300 mm Accuracy: See Table 2	Checked against a known length
Flatness for TI that indicates in 100 µin	Range: N/A Accuracy: 100 µin over entire base length	Verified with an Optical Flat
Flatness for TI that indicates in 0.001 inch	Range: N/A Accuracy: 0.001 inch over entire base length	Verified with an Electronic Height Gage
Flatness (Caliper Type)	Range: N/A Accuracy: 50 µin	Checked with an Optical Flat
Parallelism of Anvil to Spindle	Range: N/A Accuracy: See Table 2	Verified with Optical Parallel
	Range: N/A Accuracy: See Table 2	Verified with Gage Blocks or Inside Micrometer
Straightness of Micrometer Rod	Range: N/A Accuracy: .003 in/in	Verified with an Electronic Height Gage

2 EQUIPMENT REQUIREMENTS:

	Noun	Minimum Use Specifications	Calibration Equipment	Sub-Item
2.1	GAGE BLOCK SET	Range: 0.05 to 4.0 in Accuracy: 20 µin from stated Value	L.S. Starrett Co. 36	Mitutoyo 81

	Noun	Minimum Use Specifications	Calibration Equipment	Sub-Item
2.2	GAGE BLOCK SET	Range: 5 to 20 in Accuracy: 5 µin per in	L.S. Starrett Co. 8	Mitutoyo 8
2.3	OPTICAL FLAT	Range: 6 in Accuracy: 6 µin	Davidson Optronics D617-6Q-1D	
2.4	MONOCHROMATIC LIGHT	Range: N/A	Van Keuren C2	
2.5	ELECTRONIC HEIGHT GAGE	Range: 0.0004 Accuracy: 1 div	Federal Products Corp. 230P-123	
2.6	MIKE MASTER	Range: 0 to 3 in Accuracy: 100 µin	L.S. Starrett Co.	
2.7	V BLOCK (2 EA)	Range: 1 3/8 X 1 3/38 X 1 in Accuracy: 300 µin	Taft Pierce 9128	
2.8	SUPERMICROMETER	Range: 0 to 10 in Accuracy: 100 µin	Pratt & Whitney 2100	
2.9	LAPPING KIT	Range: N/A	Van Keuren 50	
2.10	INSIDE MICROMETER	Range: N/A		
2.11	SURFACE PLATE	Range: 24 X 36 Accuracy: Grade A	Rahn	
2.12	ALCOHOL (C_2H_5OH)	Range: N/A	N/A	
2.13	OPTICAL PARALLEL SET SIZE 1	Range: 0.5000 in thick Accuracy: 4 µin	Van Keuren OP 2B	
	SIZE 3	Range: 0.5125 in thick Accuracy: 4 µin		
2.14	THREAD PLUG GAGES (CALIBRATED)	Range: 1 to 6 in Accuracy: Class X and Class W	Local Purchase	
2.15	ZERO SETTING STANDARD	Range: 1 to 5 in Accuracy: 100 µin	Local Purchase	

3 PRELIMINARY OPERATIONS:

3.1 Review and become familiar with entire procedure before beginning calibration process.

WARNING

Unless otherwise designated, and prior to beginning the Calibration Process, ensure that all test equipment voltage and/or current outputs are set to zero (0) or turned off, where applicable. Ensure that all equipment switches are set to the proper position before making connections or applying power.

WARNING

Alcohol is an eye and skin irritant. Use protective equipment (chemical splash goggles and gloves) where potential of splash and skin contact may occur. Failure to do so may result in injury. If eye contact should occur, flush well with water and seek immediate medical attention.

WARNING

Alcohol is a flammable liquid: may be ignited by heat, sparks, or flames. Vapors may travel to a source of ignition and flash back. Alcohol burns with an almost invisible flame.

NOTE

1 µin = 0.000001 in

3.2 Ensure the all TI measuring surfaces are free of dirt, nicks and burrs, and that TI can be adjusted through its entire range with no signs of sticking or binding. Clean the TI and Gage Blocks as required with alcohol and lint free wipers.

3.3 If the temperature in the calibration area is not 68 ±1°F, we must calculate the accuracy of the Micrometer. Each Micrometer will have its own accuracy statement, because of the thermal effects on length outside 68°F. Some factors to consider are as follows: room temperature, material coefficient of thermal expansion (CTE), gage block length, gage block calibration uncertainty. Use the following formula to calculate the accuracy statement:

Facts: 10 inch Micrometer
10 inch Gage Block
Material of Gage Block: Stainless Steel
Coefficient of Thermal Expansion (CTE) for stainless steel: 6.4 µin/in/°F
Gage Block Uncertainty: 10 µin
Room Temperature: 74°F

$$\textit{Accuracy of Micrometer} = (((\textit{Gage Block Length}) \times (\textit{Room Temperature} - 68°F) \times (\textit{CTE of Gage Blocks}))^2 + ((\textit{Gage Block Length}) \times (\textit{Room Temperature} - 68°F) \times (10\% \textit{ of CTE of Gage Blocks}))^2 + ((\textit{Gage Block uncertainty calibration certificate}))^2)^{1/2}$$

Accuracy of 10 inch Micrometer = $(((10\ in) \times (74°F - 68°F) \times (6.4\ \mu in/in/°F))^2 +$
$((10\ in \times (74°F - 68°F) \times (0.10 \times 6.4\ \mu in/in/°F))^2 \times +(10\ \mu in)^2)^{1/2}$
$= ((10 \times 6 \times 6.4)^2 + (10 \times 6 \times 0.10 \times 6.4)^2 + 100)^{1/2}$
$= ((384)^2 \times (38.4)^2 + 100)^{1/2}$
$= (147456 + 1474.6 + 100)^{1/2}$
386.0 μin (*this number has a coveage factor of 2*)

We must also use the increments of the TI as increments to the accuracy statement. If the TI has a resolution and accuracy of 100 µin. The accuracy increments of our calibration will be 100 µin, 200 µin, 300 µin and so forth. We always round up to the nearest increment, so our accuracy calculated above is 400 µin.

Using the above formula we will give an example of up to a 12 inch Micrometer calibration at 74°F. The resolution of the Micrometer is 100 µin. Gage blocks up to 4 inches have an uncertainty of 8 µin and gage blocks over 4 inches have uncertainty of 1 µin/in.

Micrometer	Accuracy	Number of Gage Blocks	Formula Accuracy
1 inch	100 µin	1	39.4 µin
2 inch	100 µin	1	77.6 µin
3 inch	200 µin	1	116.1 µin
4 inch	200 µin	1	154.6 µin
5 inch	200 µin	1	193.1 µin
6 inch	300 µin	1	231.7 µin
7 inch	300 µin	1	270.3 µin
8 inch	400 µin	1	308.8 µin
9 inch	400 µin	2	347.5 µin
10 inch	400 µin	1	386.0 µin
11 inch	500 µin	2	424.7 µin
12 inch	500 µin	1	463.3 µin

3.4 When checking Special Purpose Micrometers for linearity, it may not be possible for the Micrometer to indicate the applied length due to the shape of the Anvil and Spindle. When this is true, record the difference between the applied length and the Micrometer indication. All succeeding readings shall have the same difference. In some cases a spacer between the Gage Blocks and Anvil or Spindle may be required to avoid damage to the Gage Blocks. Always use the same point on the spacer to avoid errors in the Micrometer indication. Special purpose Anvil and Spindle faces (rounded, pointed, regrooved, etc.) cannot be calibrated for flatness due to design. Complete the linearity checks using the appropriate sections.

3.5 Let Micrometers stabilize at room temperature for two hours for those that have an accuracy of 0.001 inch and four hours for those that have an accuracy of 0.0001 inch

3.6 Check Measuring Rods accompanying depth micrometers for bends by hand rolling on the Surface Plate. Bent rods are cause for rejection since they can cause sticking when inserted in the micrometer Spindle.

NOTE

Other rods accompanying Depth Micrometers need only be checked at one spot within the rods range. Micrometer Head Linearity should be checked with the shortest rod.

3.7 The TI must be calibrated in an environment that allows the tolerance listed in Table 2 under the 68 ±1°F Column to be achieved. If it is not possible due to lack of facilities, the Limited Certification Label must be used and annotated with the calibration accuracy as calculated using the formula in step 3.3.

3.8 To ensure uniformity in the calibration of the ratchet type micrometers, the technician should place the micrometers on to the reference plane of the standard, holding it firmly in place with one hand. Utilizing a slight rocking motion on the frame of the micrometer, simultaneously closing the TI ratchet until there is no more rocking motion, indicating that the axis of the micrometer is perpendicular to the reference plane.

3.9 The Dial Indicator on Dial Depth Gages shall be calibrated using T.O. 33K6-4-889-1. The Depth Gage Base Flatness and Rods shall be calibrated using the applicable sections of T.O. 33K6-4-15-1.

3.10 Section 4.8 Micrometer Head Calibration will be used for Micrometer Heads, this section is not required for the calibration of standard caliper and depth Micrometers.

3.11 Use only the portions of the calibration procedure applicable to the TI being calibrated.

3.12 If using the Mike Master to calibrate linearity of Outside Micrometers, it will be necessary to perform either para 4.2 or 4.3.

4 CALIBRATION PROCESS:

NOTE

Unless otherwise specified, verify the results of each test and take corrective action whenever the test requirement is not met, before proceeding.

NOTE

Personnel inexperienced in reading Optical Flat fringe lines should consult T.O. 32-1-201, Section 2-347. Remember that regardless of size, spacing or shape of fringe lines, if fringes are read properly, the same reading will result. Therefore, a fringe pattern should be obtained that can be easily interpreted by the calibrating technician.

4.1 FLATNESS TEST:

4.1.1 Place the TI Anvil under the Monochromatic Light Place the Optical Flat on the TI Anvil measuring surface and verify the flatness.

NOTE

Unless the calibrating technician is experienced in reading Optical Fringe Lines, the entire measuring surface of the TI should be covered by the Optical Flat To convert Monochromatic Light fringes to dimensional measurements use the following.

Types of Monochromatic Lights

Light Source	Wave Length µin	Wave Length nm	Length/Fringe µin	Length/Fringe nm
Helium-Neon Laser (Bright Red)	24.9	632.8	12.5	316.4
Sodium Vapor (Yellow)	23.2	589.3	11.6	294.7
Mercury Vapor (Green)	21.5	546.1	10.8	273.1
Helium Discharge (Yellow-Orange)	23.1	586.7	11.5	293.4

4.1.2 Repeat step 4.1.1 on the TI Spindle measuring surface.

4.1.3 The TI Anvil and Spindle measuring surfaces must be flat within 50 µin.

4.2 PARALLELISM CHECK: (PREFERRED METHOD)

NOTE

Parallelism Check (Preferred Method) can only be used for 0 to 1 inch micrometers. All other sizes must be checked using the Gage Block Method referenced in para 4.3, Parallelism Check (Optional Method).

4.2.1 The Optical Parallel test requires a very clean, flat and smooth surfaces.

4.2.2 Wring an Optical Parallel to the TI Anvil. Place the TI under the Monochromatic Light. The bands on the TI Anvil should either disappear or form an edge circle.

4.2.3 Using the Spindle load control, contact the Optical Parallel with the TI Spindle. Without disturbing the TI or the Optical Parallel, rotate the TI and read the band pattern on the TI Spindle. Record the number and direction of the bands for this Spindle position.

4.2.4 Repeat step 4.2.3 using the remaining Optical Parallel.

4.2.5 The values recorded in steps 4.2.3 and 4.2.4 must be less than 100 µin.

4.3 PARALLELISM CHECK: (OPTIONAL METHOD)

NOTE

The minimum distance that the Gage Block should be inserted should be at least 0.05 inch, or 1/4 of the diameter of the anvil and spindle.

4.3.1 Using the appropriate size Gage Block, make (4) four measurements at (4) four different points on the Anvil and Spindle as shown in Figure 2. All measurements shall meet the requirements of Table 2 for the TI, if calibrated in a 68°F room. The accuracy of the Micrometer will be determined if calibrated in all other environments.

4.3.2 Repeat step 4.3.1 using a Gage Block stack of a size that will not allow the Spindle to fall in the same position as the Gage Block stack selected in step 4.3.1

4.4 DEPTH MICROMETER BASE FLATNESS:

NOTE

Do not lock head without a rod in place. This could damage the lock and cause the rods to bind

NOTE

If Base Depth Micrometer, (.001 inch resolution) shows signs of wear use step 4.4.2. If Base shows no signs of wear, use steps 4.4.3 thru 4.4.4.

4.4.1 On Depth Micrometer with a resolution of 100 µin per division, use a Monochromatic Light and Optical Flat to measure the flatness of the Base to the tolerances listed in Table 1.

4.4.2 On Depth Micrometer with a resolution of 0.001 inch per division, sit the Base on two equal Gage Blocks as shown in Figure 1, View B assuring the Base sits on the Gage Blocks from 1/8 to 1/2 inch.

4.4.3 Set the Depth Micrometer on a Gage Block as shown in Figure 1 View A. Record the Vernier readings.

4.4.4 Set the Depth Micrometer on two Gage Blocks that are the same size as first Gage Block, as shown in Figure 1 View B. The vernier shall read within the tolerance listed in Table 1 of reading recorded in step 4.4.3.

4.5 ZERO SETTING CHECK:

4.5.1 ZERO the Micrometer by bringing Spindle and Anvil together or by inserting an appropriate Gage Block stack between the Spindle and Anvil. Adjust to as near exact zero as possible. The zero reading must not exceed 1 division.

4.5.1 Zero the Depth Micrometer by bringing the Micrometer base in contact with a known flat surface (Gage Block face). Adjust Vernier to as near exact zero as possible. The zero reading must not exceed 1 division.

4.6 LINEARITY CALIBRATION:

NOTE

When calibrating outside measuring devices with a range of 3 inches or less with a 0.001 accuracy the MIKE MASTER can be used in place of GAGE BLOCKS. Use the appropriate steps of the MIKE MASTER, the size of the steps do not have to agree with the size of the GAGE BLOCKS listed in the procedure.

NOTE

After the TI's Linearity check is performed in this para, the "Zero Setting check," for additional rods accompanying the TI can be checked using a Calibration Master (P/N 25-2007-00) for Depth Micrometers. For rods above 6.500 inches, the technician will be required to use Gage Blocks.

4.6.1 Construct a Gage Block stack that will cause the TI measuring faces to be adjusted apart from each other by 0.120 inch.

4.6.2 Measure the Gage Block stack with TI and ensure that reading of TI agrees with height of Gage Block stack within tolerances called out in Table 2, if calibrated at 68°F. If calibrated in an environment other than 68°F, it must be within the calculated accuracy determined in step 3.3 for your environment.

4.6.3 Repeat step 4.5.3 for Gage Block stacks of 0.256, 0.512, 0.768, and 0.950. Micrometers with limited ranges used for special applications should be calibrated at zero, half scale and full scale using the appropriate Gage Blocks

4.6.4 If TI is accompanied by interchangeable Anvils or Spindles, each Anvil or Spindle must be inserted in TI and checked for flatness (para 4.1), parallelism, and a zero setting check made (step 4.5.1 and 4.5.2).

4.7 ZERO CHECK RODS THAT ACCOMPANY TI:

NOTE

Zero Check Rods or Disks that accompany Micrometers with fixed Anvils should not be calibrated. Zero check Rods or Disks that accompany micrometers with changeable Anvils should be calibrated using T.O. 33K6-4-369-1. If Zero Check Rods or Disks are not calibrated annotate same on Limited Certification Label.

4.8 BENT DEPTH MICROMETER ROD CALIBRATION:

NOTE

Perform steps 4.8.1 through 4.8.9 only for rods suspected of being bent as determined in step 3.6.

4.8.1 Clamp the middle of the measuring rod to the V Block.

NOTE

On long rods it may be necessary to use two V Blocks to prevent the rod from drooping. When using two (2) V Blocks do not clamp the rods to the V Block.

4.8.2 Set the Electronic Height Gage to the appropriate range to measure 0.001 inch.

4.8.3 Position the Gagehead on top of the end of the measuring rod that is inserted in the Spindle. Zero the meter using the zero adjustment.

4.8.4 Reposition the Gagehead on top the measuring rod 3 1/2 inches from the end. The meter shall indicate 0.0035 inch or less.

NOTE

This part of rod fits into micrometer.

4.8.5 Rotate Rod 90° and repeat steps 4.8.3 and 4.8.4. Repeat for 180° and 270°.

4.8.6 Reposition the Gagehead on top of the end of the measuring rod. Rezero the meter.

4.8.7 Reposition the Gagehead along the length of the rod and record readings for 0°, 90°, 180°, and 270°. The meter shall indicate less than 0.003 inch per inch of measuring.

4.8.8 Remove measuring rod from V Block.

4.8.9 If rod passed, do length calibration

4.9 MICROMETER HEAD CALIBRATION:

4.9.1 Secure the shank of the TI to a V Block and position in its vertical

4.9.2 Zero the Micrometer Head by bringing the measuring surface in contact with a known flat surface (Gage Block face).

4.9.3 Apply Gage Block stacks equivalent to 25, 50, 75, and 95% of the range of the TI.

4.9.4 TI must not exceed 1 division.

NOTE

A supermicrometer, along with a locally fabricated holding block consisting of several holes of different diameters for mounting of the TI shank may be used in place of the V Block method.

4.10 THREAD MICROMETER CALIBRATION:

4.10.1 Zero the TI using the appropriate Zero Setting Standard.

4.10.2 Verify Pitch Indication using the appropriate size calibrated Thread Set Plug Gage that is approximately the mid-range of the TI.

NOTE

Thread Micrometers with, 0.001 inch divisions, require the use of the Class X Thread Set Plug Gage. Thread Micrometers with 0.0001 inch divisions, require the use of the Class W Thread Set Plug Gage.

NOTE

Calibration of the Zero Setting Standards is not required as verification of Pitch Indication and linearity is accomplished using calibrated Thread Plug Gages.

NOTE

If the appropriate Thread Plug Gages are not available, Linearity may be verified using Gage Blocks and a Thread Measuring Wire in the TI V anvil.

4.10.3 Measure the Thread Plug Gage and verify that the measurement is within the actual Thread Plug Gage size with the required TI tolerance.

4.10.4 Repeat steps 4.10.1 and 4.10.2 at approximately 25% and 75% of the TI range. All readings must be within the required tolerance for the TI being calibrated.

4.10.5 Disconnect and secure all equipment.

Table 2.

Range of Caliper or Size of depth Micrometer	Lab Temperature 68° ±1°F
	Tolerances for Resolution/DIV of 0.0001
0 - .250	0.0001
0 - .500	0.0001
0 - 1	0.0001
1 - 2	0.0002
2 - 3	0.0002
3 - 4	0.0002

Table 2. (Cont.)

Range of Caliper or Size of depth Micrometer	Lab Temperature 68° ±1°F
	Tolerances for Resolution/DIV of 0.0001
4 - 5	0.0002
5 - 6	0.0002
6 - 7	0.0003
7 - 8	0.0003
8 - 9	0.0003
9 - 10	0.0003
10 - 11	0.0003
11 - 12	0.0003
	Tolerances for Resolution/DIV of 0.001 in
0 - .250	0.001
0 - .500	0.001
0 - 1	0.001
1 - 2	0.001
2 - 3	0.001
3 - 4	0.001
4 - 5	0.001
5 - 6	0.001
6 - 7	0.001
7 - 8	0.001
8 - 9	0.001
9 - 10	0.001
10 - 11	0.001
11 - 12	0.001
12 - 18	0.001
18 - 24	0.001
24 - 30	0.001
30 - 36	0.001

Table 2 (Cont.)

Range of Caliper or Size of depth Micrometer	Lab Temperature 68° ±1°F
	Tolerances for Resolution/DIV of 0.0002
0 - 1	0.0002
1 - 2	0.0002
2 - 3	0.0002
3 - 4	0.0002
4 - 5	0.0002
5 - 6	0.0002
6 - 7	0.0004
7 - 8	0.0004
8 - 9	0.0004
9 - 10	0.0004
10 - 11	0.0004
11 - 12	0.0004

Range of Caliper or Size of depth Micrometer	Lab Temperature 68° ±1°F
	Tolerances (mm) for Resolution/DIV of 0.001 mm
0 - 13	0.004
0 - 25	0.008
25 - 50	0.008
50 - 75	0.008
75 - 100	0.012
100 - 125	0.008
125 - 150	0.008
150 - 175	0.012
175 - 200	0.012
200 - 225	0.012
225 - 250	0.012

Table 2. (Cont.)

Range of Caliper or Size of depth Micrometer	Lab Temperature 68° ±1°F
	Tolerances (mm) for Resolution/DIV of 0.001 mm
250 - 275	0.0012
275 - 300	0.0012

Range of Caliper or Size of depth Micrometer	Lab Temperature 68° ±1°F
	Tolerances for Resolution/Div of 0.01 (mm)
0 - 13	0.01
0 - 25	0.01
25 - 50	0.01
50 - 75	0.01
75 - 100	0.01
100 - 125	0.01
125 - 150	0.01
150 - 175	0.02
175 - 200	0.02
200 - 225	0.02
225 - 250	0.02
250 - 275	0.02
275 - 300	0.02

CALIBRATION PERFORMANCE TABLE

Not Required

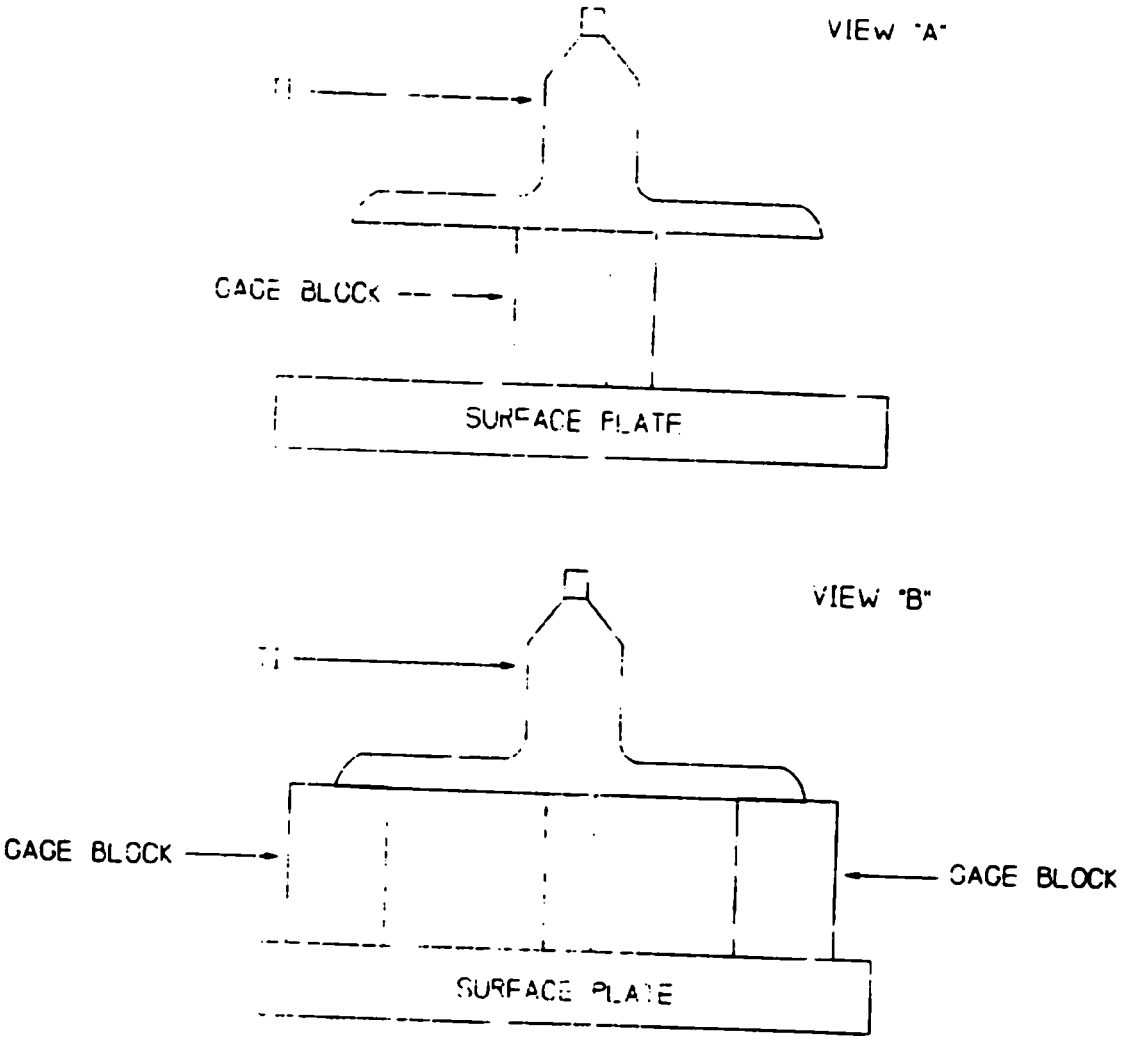
VIEW "A"
GAGE BLOCK
SURFACE PLATE
VIEW "B"
GAGE BLOCK
GAGE BLOCK
SURFACE PLATE

Figure 1.

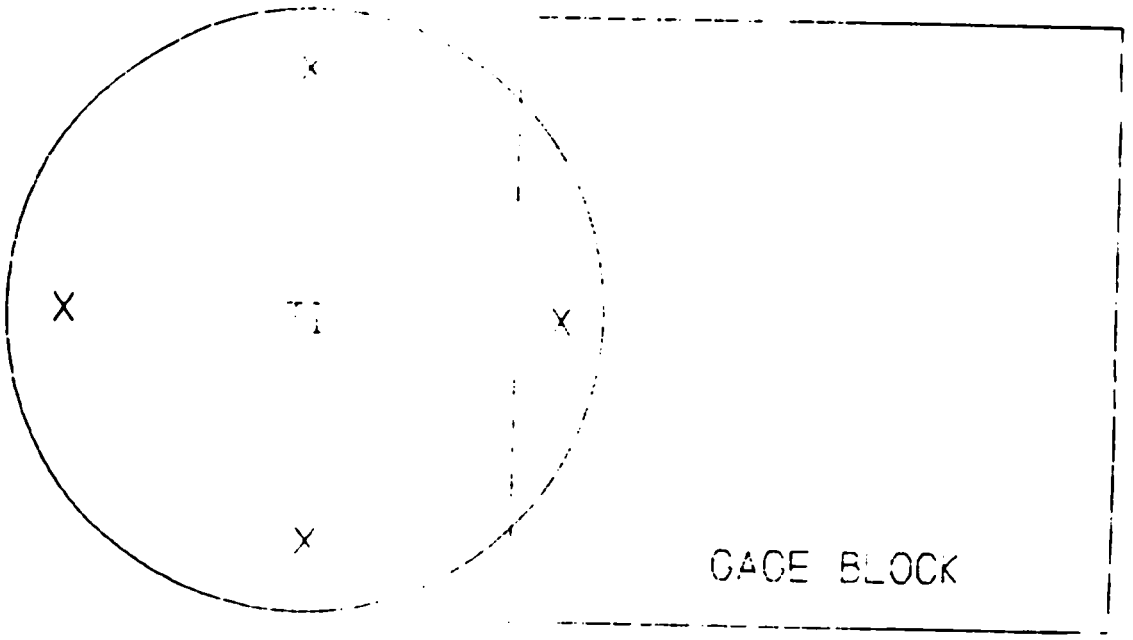

Figure 2.